CLIMATE CHANGE AND VECTOR-BORNE DISEASES : A REVIEW OF 2011 DENGUE OUTBREAK IN PAKISTAN

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ABSTRACT

Dengue (dengue hemorrhagic fever) has emerged as an epidemic in Pakistan, since 1994. The recent dengue outbreak in year-2011 has drawn serious attention, which has affected over 16,000 people, out of which 306 are reported to have died. By analyzing the available scientific research this paper reviews the consequences which have resulted in increased activity of vector, i.e. 'Aedesaegypti' during year-2011.

The paper establishes a link of the 2011 dengue outbreak with hydro-meteorological events which have occurred over the year-2011 which are attributed to climate change. The paper concludes that suitable climatic conditions prevailed during the year which promoted the insect's survival time and habitat but also its replication and maturation, leading to un-precedented epidemic outbreak of dengue. The paper also proposes appropriate policy planning and institutional, technical, operational, administrative and social recommendations to manage and control any future dengue outbreaks in Pakistan.

1. INTRODUCTION

Dengue is an acute febrile viral disease that has drawn serious attention in recent decades. Dengue is caused by 'dengue fever virus (DENV)' which is aribo-nucleic acid (RNA) virus of the family '*Flaviviridae*' belonging to genus '*Flavivirus*'. This virus is transmitted to humans by mosquitoes belonging to genus '*Aedes'* which are widely distributed in sub-tropical and tropical regions of the World. Dengue is classified as a 'major global health threat' and nearly 2.5 billion people (two fifths of the World's population) is now at risk from dengue. The disease is endemic in more than 100 countries in Africa, the Americas, the Eastern Mediterranean, South-east Asia and the Western Pacific. The countries in South-east Asia and Western Pacific region are the most seriously affected because of the tropical climate and poor living conditions of these regions[3].

The symptoms of dengue virus include fever, headache, muscle and joint pains (due to which it is also sometime referred to as 'break-bone fever'), severe eye pain (behind eyes), skin rashes (maculopapular rash) and severe itching. During dengue fever hemorrhagic complications may also appear such as bleeding from the gums, nose bleeds, and bruising[4]. In some cases the disease develops into the life-threatening 'dengue hemorrhagic fever (DHF)' resulting in bleeding, low levels of blood platelets and blood plasma leakage or may lead into 'dengue shock syndrome' where dangerously low blood pressure associated by circulatory failure occurs[5].

Reviewing the trends and events this paper provides an overview of the year-2011 dengue outbreak in Pakistan and attempts to establish a relationship of this incidence with the global phenomenon of climate change.

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3. WHO (2009) Dengue and dengue hemorrhagic fever, Media center, Fact sheet *http://www.who.int/mediacentre/factsheets/fs117/en/*

4. Lloyd., S.L. (2003). Best Practices for Dengue Prevention and Control in the Americas. Prepared for the USAID Bureau for Latin America and Caribbean under EHP Project 26568/E.V.4.LACDENGUE *http://www.ehproject.org/PDF/Strategic_papers/SR7-BestPractice.pdf*
5. Centers for Disease Control and Prevention (CDC): Dengue. *http://www.cdc.gov/Dengue/epidemiology/index.html*

1.1. Epidemiology:

Dengue / dengue hemorrhagic fever is present around the World predominantly in urban and semi-urban areas. Several factors have combined to produce epidemiological conditions in developing countries (tropics and sub-tropics) that favor viral transmission by the vector i.e. *Aedesaegypti*. Inadequate basic urban infrastructure (e.g. un-reliable water supply that leads householders to store water in containers close to homes) and increase in volume of solid waste such as discarded plastic containers and other abandoned items which provide dengue larval habitat for in urban areas thus provides conducive conditions for dengue outbreak[6].

Geographical expansion of the mosquito has been aided by international commercial trade particularly in used tyres which easily accumulate rainwater and remain un-noticed. Increased air travel and breakdown of vector control measures (bio-safety protocols) have also contributed greatly for dengue.

1.2. Transmission:

Dengue virus is transmitted to humans through the bites of infective female *Aedes* mosquito particularly by '*A. aegypti'* which is one of the most efficient vectors because it is highly anthropophilic and thrives in close proximity to humans. Other disease transmitting species include '*A. albopictus'* '*A. polynesiensis'* and '*A. scutellaris*. All of these species have a particular ecology, behavior and geographical distribution. Once infected humans become the main carriers and multipliers of the virus serving as a source of the virus for un-infected mosquitoes. The virus circulates in the blood of an infected person for 2-7 days after extrinsic incubation. At approximately the same time the person starts developing symptoms of fever. Patients who are already infected with the dengue virus can transmit the infection via female *Aedes* mosquitoes as soon as the first symptoms appear[7].

1.3. Climate change and Dengue:

Climate Change is rapidly unfolding environmental and developmental challenges for the World most of which have multi-natured catastrophic dimensions. Pakistan is amongst the most vulnerable nations and has been rated as 'at extreme risk' by a Climate Change Vulnerability Index (CVI) which has ranked Pakistan at number 16th in the list of 'most vulnerable countries of the World' over the next 30 years[8].

Global warming threatens to further exacerbate the spread of many infectious diseases because increases in heat, precipitation and humidity which can foster better conditions for tropical and subtropical insects to survive and thrive in places previously in-hospitable to those diseases. Warmer temperatures boost the speed of development of adult mosquitoes increasing their numbers. Female mosquitoes bite more frequently in hotter temperatures and warmer winters enable mosquitoes to survive in areas that were formerly too cold. Higher temperatures also shorten the time it takes for the virus inside the mosquito to develop and become infective[9].

The effects of global warming on human health besides others are visible in form of vector borne infectious diseases such as dengue fever is mainly attributed to the expansion of the infested areas of vector (mosquitoes) that provides conducive conditions for increasing their number and also expansion of feeding activity. Changes in climate that can affect the trans-

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6. Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control (2009) : World Health Organization (WHO) and the Special Programme for Research and Training in Tropical Diseases (TDR) *http://whqlibdoc.who.int/publications/2009/9789241547871_eng.pdf*
7. World Health Organization (WHO) Programmes and projects: Dengue. *http://www.who.int/denguecontrol/human/en/index.html*
8 Big Economies of the Future-Bangladesh, India, Philippines, Vietnam and Pakistan-most at risk from climate change(2010) http://maplecroft.com/about/news/ccvi.html

9. Ichiro Kurane, MD (2010). The Effect of Global Warming on Infectious diseases. Public Health Research Perspective. Volume 1, Issue 1, Page 4-9*http://www.kcdc-phrp.com/article/S2210-9099%2810%2900005-6/fulltext*

mission of vector-borne infectious diseases include temperature, humidity and altered rainfall[10]

1.4. Objectives:

The objectives of this review paper are.

i. Conducting a desk review of the circumstances which have resulted in dengue outbreak in Pakistan during year-2011.

ii. Through available information, establish a relationship of this incidence with the phenomenon of climate change.

iii. Propose appropriate policy planning and institutional, scientific / technical, operational/administrative and social recommendations to control and/or better manage any future dengue outbreaks in Pakistan.

2. REVIEW OF 2011- DENGUE OUTBREAK IN PAKISTAN

Over the past few years, Pakistan has emerged as a region of endemic dengue activity. The first outbreak of dengue fever (DF) was reported in Karachi in year-1994. Later, another outbreak emerged in the upper regions of Punjab in year-2003. There have been regular epidemics with an increasing number of dengue cases in Karachi from year-2005 onwards.

The 2011 dengue outbreak in Pakistan especially across Lahore and other cities of Punjab, including Faisalabad, Sheikhupura, Rawalpindi and Multan etc. have drawn serious attention. A total of 16,000 people have been affected by October, 2011, out of which more than 306 have died. Highest number reported cases were from Lahore that is nearly 14000[11].

Monsoon season, hot and humid climate favors mosquitoes breeding. These are main reasons due to which epidemics of dengue tend to coincide with the rainy season[12]. Subsequent floods across the country have indirectly lead to an increase in dengue through the expansion in the number and range of habitats like standing water caused by rainfall.

In dengue an increase in temperature not only affects the insect's survival time and habitat but also its replication, maturation and infective periods by providing suitable conditions for mosquito survival[13]. An overall warmer trend observed in different parts around the country has allowed these vectors to survive over winter migrate into areas previously free of disease or to trigger exacerbation of transmission in endemic areas.

Global warming is anticipated to increase the amplitude of the El Niño / southern oscillation (ENSO) resulting in marked changes in precipitation patterns. High frequency of rainfall events ensure that breeding places like abandoned automobile tires, scupper drains, pots, buckets, cans and stagnant water in potted plants and the trays underneath them and also garbage dumps etc. creates larval habitats for mosquito thereby expanding adult mosquito population[14].

Studies show that the optimal temperature for dengue transmission is over 20°Celsius (°C)[15]. At. temperatures below 20 °C (68° Fahrenheit), the dengue mosquito cannot complete its growth cycle whereas temperature range below than 20 °C upto freezing point are unfavorable for

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10. Ichiro Kurane, MD (2010). The Effect of Global Warming on Infectious diseases. Public Health Research Perspective. Volume 1, Issue 1, Page 4-9
http://www.kcdc-phrp.com/article/S2210-9099%2810%2900005-6/fulltext
11. *Government of Punjab (Pakistan). Combating Dengue. http://dengue.punjab.gov.pk/?q=system/files/Summary_12_Oct.pdf*
12. *Muhammad Shamim (2010). Frequency, Pattern and Management of Acute Abdomen in Dengue Fever in Karachi, Pakistan. Asian Journal of surgery, Vol 33 No. 3 http://linkinghub.elsevier.com/retrieve/pii/S101595841060019X?via=sd&cc=y*
13. L.P. Lounibos et.al (2002) Does temperature affect the outcome of larval competition between *Aedesaegypti* and *Aedesalbopictus*? Journal of Vector Ecology 27(1):86–95.*http://dhf.ddc.moph.go.th/abstract/s11.pdf*

14. *Cayan, D.R, et. al (1999) ENSO and hydrologic extremes in the Western United States. J. Climate 12, 2881–2893.http://journals.ametsoc.org/doi/pdf/10.1175/1520 0442%281999%29012%3C2881%3AEAHEIT%3E2.0.CO%3B2*
15. *Brazil: Dengue Fever Case Study (OXITEC). http://www.oxitec.com/our-targets/dengue-fever-and-chikungunya/brazil-dengue-fever-case-study*

mosquitoes. Contrary to prevailing suitable conditions during 2011 an extremely hot ambient temperature results in mortality of mosquitoes while cold climate destroys larvae and eggs.

Pakistan Meteorological Department reported 10% above normal rainfall in 2011 in northern half of Pakistan including Kashmir, Punjab and Khyber-Pakhtunkhwa provinces at occasions by the interaction of easterly and westerly systems resulting in heavy downpour in these areas[16]. Average for the monsoon rainfall in Lahore is 470.1 millimeters (18.51 inches) but in 2011 a total of 1,439.8 millimeters (56.69 inches) was recorded[17] which is well above the yearly average.

In addition to climatic factors the incidence of dengue outbreak in Pakistan is influenced by many demographic and societal factors like population growth, un-planned urban areas and inadequate public-health systems and in-appropriate facilities for handling and storing water.

3. CONCLUSIONS

The incidence of 2011 dengue outbreak across Pakistan besides other factors is primarily attributed to global climate change which has intensified the epidemic by providing favorable conditions for breeding of vector mosquitoes. Their transmission is also climate sensitive as mosquitoes require standing water to breed. Humid conditions, higher rainfall, the degree of urbanization were found to co-relate with increasing risk of dengue fever[18] which generally prevailed in central Punjab during May-October, 2011.

A favorable climate necessary for disease transmission is moist and moderately warm has prevailed during 2011 in Pakistan. Other factors for an epidemic to trigger were i.e. (i) an increase in vector populations poor preparedness and susceptible human population, (ii) Poor urban planning and other societal factors including practices to store water in open containers (iii) lack of public health infrastructure and awareness among people and capacity to adapt is weakest which has contributed to emergence of dengue in year-2011.

Thus keeping in view all the above factors it is concluded that in the year-2011 conductive climatic conditions for the dengue vector prevailed over Pakistan which resulted in disease outbreak particularly across Punjab province. If a comprehensive plan for prevention and control is not followed dengue and other vector borne diseases would continue to be a problem in days to come in a scenario where climate change and other associated changes in weather patterns are anticipated to be more pronounced.

4. RECOMMENDATIONS

The following set of a policy to pre-empt the outbreak of Dengue Disease Containing technical, operational, administrative and social recommendations are as well as to control and manage any future dengue outbreak may be implemented.

4.1. Policy Planning and Institutional Coordination Measures

i. Sound institutional preparedness under clearly devised policy guidance is required both at federal and provincial level. In order to control and / or manage the vector outbreak, clearly defined roles and needs to be devised and institutional responsibilities must be fixed. Sound institutional coordination mechanisms must also be put in place.

ii. There is a need to further strengthen Pakistan's role in climate change diplomacy through projecting incident like 2011-dengue outbreak. This would project Pakistan's stance as one of the most vulnerable nations thus influencing the global dialogue.

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16. *National Weather Forecasting Center, Pakistan Meteorological Department http://pakmet.com.pk/MON&TC/Monsoon/monsoon%282010%29.html*

17. *Pakistan Meteorological Department (PMD), 2011*
http://www.pakmet.com.pk/FFD/index_files/daily/rainfallsep1.htm
18. Wu, P. et al. (2009).Higher temperature and urbanization affect the spatial patterns of dengue fever transmission in subtropical Taiwan. Science of the Total Environment. 407, 2224-2233.
http://www.climate.org/topics/health.html

iii. Active participation of inter-sectoral partners is needed right from the programme planning to implementation and evaluation for strengthening the policy response. To deal with the health effects of the disease, the health sector must be engaged in preparedness activities at all levels international, regional, national, local and community.

iv. Short to medium-term (up to one year) and long-term (from one upto 5 years) multi-sectoral strategic plans must be devised at provincial level with sufficient allocation of financial and administrative resources to adopt a comprehensive approach covering public health and safety administrative and environmental measures.

v. Integrating climate change concerns in health related policies and action plan at national as well as provincial level is essential. This would enable to set priorities for mobilizing requisite capacities and resources.

vi. Efficient and effective policy implementation and feedback, monitoring mechanisms must be put in place to ensure implementation of the policy measures and also ensure effective coordination amongst all relevant institutions, bodies and maintain federal to provincial coordination.

4.2. Scientific, Technical and Administrative Measures

i. High-class collaborative scientific research on the epidemiology of vector and other factors such as climatology needs to be conducted to further understand exact dynamics of the vector and factors that influence such out-breaks. Policy studies backed by past, current and forecasted climate change conditions with historical epidemics must be conducted in order to reveal the risk of dengue in days to come. The results of such research could supplement effective decision making by supporting action planning.

ii. Research on promotion of naturally occurring or introduction of new biological control agents for mosquitoes (parasitoids) needs to be adopted for controlling the vector. The carefully selected measures may include importation, augmentation and habitat management for parasitoids.

iii. Epidemiological and entomological surveillance, outbreak investigations and meteorological forecast to anticipate climatological conditions over the year must be done to devise and support implementation of decision making and ground action. Field based research complimented by use of tools such as Geographic Information Systems (GIS) must be used to keep a track of any incidence. Such data and information would help in devising early warning systems.

On-going local research is also needed because global warming's effects on temperature and rainfall patterns can affect the risks of dengue outbreaks differently in specific areas.

iv. Institutional strengthening of all tiers is necessary to effectively implement policy and programmes particularly district administration in all 'high-vulnerable' districts must be capacitated to take necessary administrative / pre-emptive measures in this regard.

v. Institutional strengthening of research facilities and institutions related to outbreak response including hospitals must be strengthened. Necessary facilities including research equipment, medicines and others must be made available to manage any outbreak in more effective manner. Human capacities in diagnostic and analytical

methods need to be built with comprehensive training programmes including those for scientists and medical staff (doctors and paramedics).

vi. Standard case management is critical for reducing morbidity and preventing mortality due to dengue. Adoption of guidelines for clinically parasitology and needs to be

followed since transfusion of platelets in most of the cases is critical for saving lives, availability of safe blood products warrant strengthening the capacity of blood transfusion services to respond effectively during outbreaks.

vii. Strict guidelines need to be set in place for water storage and disposal particularly in urban and peri-urban areas. Efficient enforcement mechanisms needs to be adopted for keeping a check on water storage facilities tanks, ponds, fountains etc. which can offer breeding grounds for *A. aegypti.*

viii. The use of chemicals for fogging and fumigation must be strictly regulated as their negative impacts are often greater than what is intended. Indiscriminate use may be a 'populous demand' and politically leveraged but inappropriate use can counter productively increase pest resistance. Also studies suggest that very less of applied chemical is effective in eradication of mosquitoes, the rest reach destination killing non-target species (may be biological control agent) and contaminates air, water, food, humans and soil.

4.3. Social Measures

i. Human behavior and practices which leads to breeding of mosquito vector needs to be changed through continuous advocacy. Such targeted campaigns must be conducted which have high impact. Such campaigns targeting women folks, school children, service providing institutions at local levels and public at large. Role of mass media is also crucial to rope in additional support.

Involvement of local institutions (youth/welfare associations etc.) in campaigning could also help in identification and implementation of locally acceptable measures related to water handling, storage, waste and sewage disposal.

ii. Advocacy to control indoor mosquitoes population is also must for promotion of use of mosquitoes nets and insect killing sprays and repellent like liquids/coils needs to be selectively promoted.

Measures to minimize and/or limit outdoor activities particularly at peek times of vector activity (dawn and dusk in case of dengue) should be practiced. Schools and other institutions need to be particularly focused to take necessary measures in this regard.

iii. Advocacy on the impacts of climate change on the country, particularly in health sector would be instrumental for long-term campaigning against the epidemics, such as dengue.